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Conceptual Design of the Gasification of Plastic Waste for the Production of Syngas or Naphta: A Circular Approach from Plastic Waste to Renewed Polymers

I. Rossetti[1], A. Tripodi[1], F. Conte[1], G. Ramis[2]
[1]Università degli Studi di Milano, [2]Università degli Studi di Genova

Abstract

Gasification and pyrolysis are thermochemical processes proposed for the transformation of different biomass substrates into different compounds. Syngas is the main product under harsh gasification conditions, while a liquid “naptha-like” mixture is reported under milder pyrolytic conditions.

The conceptual design of different options for the valorisation of plastic wastes through either gasification and pyrolysis is in progress, by comparing the two options in the view of production of olefins and, in perspective, of renewed polymeric materials. With respect to mechanical recycling, this approach has the advantage of a more versatile reutilisation of the plastic waste, which can end in high added value products. Furthermore, it represents a better valorisation of the waste material with respect to thermal valorisation.

One of the explored routes is the gasification of a model waste material, i.e. polyethylene, to obtain syngas, which is further converted into methanol to feed a Methanol-to-Olefins pathway. The other option is the pyrolytic conversion of polyethylene according to a substantial depolymerisation/cracking reaction. If it is possible to optimise the yield of a naptha fraction, this may feed a conventional cracking unit, as such or blanded with fossil naptha, to produce light olefins.

The comparison of the two solutions is proposed in terms of conceptual process design, starting from literature experimental data of thermal conversion of polyethylene under different conditions. The kinetic model for gasification and pyrolysis is first retrieved as a power-rate lumped equation, to allow easier implementation into a reactor model into the Aspen Plus process simulator. The latter software is also used to design the whole flowsheet. The final aim of the present work will be the economic assessment of the two solutions, to conclude on their feasibility and a Life Cycle Assessment in comparison with the more conventional thermal valorisation of the raw material.